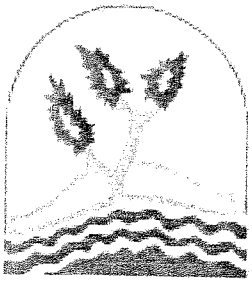

JOSHUA BASIN WATER DISTRICT

Joshua Basin Package Wastewater Treatment Plant Feasibility Report

April 7, 2006, rev. May 23, 2006
(includes addendum dated May 9, 2006)

Prepared by:

DUDEK

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Introduction

Pursuant to the request of Joshua Basin Water District, we have prepared this letter report outlining the feasibility of District acquisition, ownership, and operation of package secondary treatment plants, for the purpose of treating domestic sewage from housing developments within the District. One of the first developments to propose a package system is the Desert View Estates Development. If the District chooses to approve and assume ownership of the Desert View Estates Package Plant, it may also enter into agreements to assume the ownership of additional package plants for other planned developments.

Desert View Estates is a 61-unit housing development currently being designed near the western edge of the District, near the community of Joshua Tree. The tentative tract number for this housing development is 16529. The development will consist of single-family homes with 3 to 4 bedrooms and 2 baths. Lot sizes will be approximately ¼ acre.

In previous analyses performed by Dudek Engineering, it was estimated that the sewer flow generation from each home would average about 305 gallons per day per EDU. This is a number based on the measured water consumption within the District and an estimate of the percentage of metered water that is returned to the sewer.

Using this flow information, the package treatment facility will need to have a treatment capacity of approximately 18,700 gallons per day. The primary objective of the package plant is to treat municipal sewage to secondary effluent standards mandated by the Regional Water Quality Control Board (RWQCB), so that the effluent can be disposed of by subsurface discharge through a seepage pit or a leach field.

Alternatives Considered

In our research of treatment technologies, we considered four different package plant technologies. The first type of treatment system we researched is a stepped modular

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septic system with an attached-growth textile media. A company called AdvanTex manufactures these systems. The second system we researched is a membrane bioreactor skid as manufactured by US Filter or Zenon. The third system considered was a non-membrane, activated-sludge treatment system in an aerobic, packed bed bioreactor. This system is manufactured by a company called Biomicrobics. The fourth and final system we researched was proposed by the developer's engineer following completion of this study. This system is a packaged activated sludge treatment skid manufactured by Purestream Technologies. On page 11 of this report, there is an addendum that describes the Purestream system.

As part of our research, we contacted the Palm Desert Office of the RWQCB and spoke with John Rokke, who is directly involved in permitting wastewater treatment facilities in RWQCB Region 7. Mr. Rokke informed us that the Total Nitrogen effluent requirement for subsurface disposal will most likely be a 30-day average of 10 mg/L. The Total Nitrogen will also be required to remain below a weekly average of 15 mg/L and a daily maximum of 20 mg/L.

It is anticipated that the RWQCB will require Biochemcial Oxygen Demand (BOD) and Total Suspended Solids (TSS) effluent levels of 30 mg/L (monthly average). BOD, TSS, and Total Nitrogen are the main treatment parameters that determine the type of process and the cost of the facilities.

Stepped Modular Septic System

This product is a below-ground modular unit containing multiple septic tank modules, each with an above-grade textile media which acts as a support for microbial populations, combined with a Septic Tank Effluent Pumping System (STEPS). The textile media is an attached growth biological treatment system that acts in a similar fashion to a wastewater trickling filter.

Dudek researched this system in detail, but we have determined from our research that it will not be feasible, because it would not be able to achieve the level of nitrogen removal required by the RWQCB. The system is not capable of achieving an effluent Total Nitrogen level of less than 20 mg/L. It is important to note that the target nitrogen level of 10 mg/L being considered by the RWQCB renders many of the available technologies un-usable.

Membrane Bioreactor (MBR) Package Plant

The US Filter product is an above-ground unit that comes pre-assembled and mounted on a skid. This treatment process is used for municipal and industrial wastewater applications. The package plant utilizes membrane technology to provide high quality effluent of less than 5 mg/L BOD and 1 mg/L TSS, for influent BOD and TSS concentrations up to 350 mg/L. The package plant can be configured to provide advanced nitrogen and phosphorus removal below the limits enforced by the RWQCB.

The smallest available MBR package plant manufactured by US Filter is designed for a flow capacity of 25,000 gallons per day. As such, the system would have adequate capacity for approximately 20 additional homes, for a total of 80 homes. Larger capacity units are also available.

Technical Information – MBR Package Plant

The membrane bioreactor is a full-scale biological treatment facility that utilizes the activated sludge process by achieving clarification using submerged membranes instead of conventional clarifiers.

The treatment process on the skid begins with biological treatment in an aerobic reactor tank containing submerged hollow-fiber membranes. A vacuum is applied inside the membranes, such that the fully oxidized and nitrified water is filtered through the

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membranes. Mechanical blowers supply air to the membranes themselves, creating a crossflow condition that scours the membrane surface, preventing solids build-up.

The skid contains an influent drum screen to remove larger solids. The aeration tank on the skid contains two aerated zones: an aerobic zone with a high dissolved oxygen content and a mixed liquor suspended solids (MLSS) level of between 10,000 and 12,000 mg/L, and an anoxic zone which accepts recirculated mixed liquor from the aerobic zone. In the anoxic zone, the nitrates created in the aeration process are reduced to nitrogen gas, thereby reducing the total amount of nitrogen in the effluent. The combination of the recycle stream and the anoxic zone is what causes the denitrification (nitrogen removal) process to take place.

The major mechanical equipment on the skid would consist of influent pumps, aeration blowers, recirculation pumps, a drum screen, and an air compressor.

The approximate size of the MBR skid would be 15 feet tall, 15 feet wide, and 35 feet long. There would be a cast-in-place wet well installed underneath the skid with an approximate depth of 12 feet to 15 feet. The skid, influent wet well, and the sludge storage tank could be installed in a covered area with an approximate area of 1,500 square feet. This area could be enclosed with barbed wire fence or a masonry wall, or the facilities could be installed inside a prefabricated metal storage building, which represents the lowest cost option available for an enclosed building. Whichever enclosure is chosen, there would need to be truck access for sludge removal. There would be a concrete slab-on-grade for all of the facilities.

The system would also require a means of effluent disposal. Discussions with the RWQCB have indicated that seepage pits or leach fields are acceptable means of effluent disposal. The developer would either need to allocate space in his development for a leach field, or would need to install seepage pits, which are essentially perforated precast manholes.

The gravity sewer network of PVC pipe and manholes feeding the package plant would be designed and supplied by the developer. Typical sewer system characteristics associated with residential developments of this size are: standard 48-inch manholes at grade breaks and changes in direction; 4-inch laterals to every home sloped at a minimum of 2%; 8-inch sewer mains sloped at a minimum of 0.4%; and 6.0 feet minimum depth of cover for the sewer mains.

Membrane Bioreactor (MBR) – Additional Manufacturer

MBRs manufactured by Zenon have also gained wide acceptance in industry. Another alternative to the US Filter MBR is a membrane bioreactor manufactured by Zenon. The Zenon system would also have a mixed-liquor recycle stream back to an anoxic zone, which would allow the plant to consistently maintain effluent Total Nitrogen Levels below 10 mg/L.

Concerns About Membrane Life/Serviceability

MBR plants require regular supervision, and manufacturer claims about membrane life/serviceability are not always consistent with the true field experience of the operators. Some users have reported excessive membrane replacements and difficulty with membrane fouling, often resulting from grease. If the District chose to incur the responsibility of maintaining a membrane system, it would be prudent to conduct a detailed comparison of the membrane service life and membrane reliability of the different membrane manufacturers, based on communication with Districts that currently have the membrane bioreactors in service.

Aerobic, Packed-Bed Bioreactor

The aerobic, packed bed reactor is a viable alternative to the membrane bioreactors. In its basic form, the aerobic, packed-bed reactor is a horizontal rectangular tank that contains polyethylene, attached-growth media. The tanks are typically precast vaults. In

the center of the tank there is an airlift pipe that draws the mixed liquor across the polyethylene media and toward the bottom of the tank. The mixed liquor is drawn up the airlift pipe and spills over a distribution plate onto the top of the media, where it flows downward through the media. This recirculation causes the formation of an attached-growth bacterial layer that provides BOD reduction and nitrification. The reactor tanks can be installed in precast vaults below-grade. An above-grade blower provides aeration to the portion of the tank that contains the attached-growth media. A separate portion of the tank provides for solids settling. This portion of the tank does not contain any attached growth media.

For this application, the developer has proposed an aerobic, packed-bed reactor system manufactured by Biomicrobics. The trade name for this system is the Microfast System. For this application, the system would contain two parallel treatment trains rated at approximately 9,000 gallons per day capacity. To provide the necessary level of denitrification required to stay below 10 mg/L Total Nitrogen, there are two options available:

- Have Biomicrobics furnish the standard Microfast modules, and rely on the developer's engineer to custom-design a mixed-liquor recirculation system that recirculates mixed liquor back to the front end of the tank. Biomicrobics would not provide this recycle system; from the manufacturer's perspective it is a custom design by the end user.
- Have Biomicrobics provide a total of four tanks in each parallel treatment train as follows:

  ---The first tank would be the standard Microfast tank with the polyethylene media.

  ---The second tank would contain a modified polyethylene media with a tighter mesh, to promote the growth of nitrifying bacteria. The purpose of this aerobic tank would be to achieve full nitrification, so that all of the influent ammonia is converted to nitrates.

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----The third tank would contain polyethylene media, but no airlift and no aeration. This would be an anaerobic tank where denitrification would take place (conversion of nitrates to nitrogen gas). Methanol would need to be provided to the tank, to provide an additional BOD source for denitrification to occur.

---The fourth tank would be a smaller version of the first (aerobic) tank. The fourth tank would provide removal of the BOD introduced in the anaerobic tank.

Currently the developer's engineer has applied for a Regional Board Order to permit the Microfast system. This Regional Board order, which will be considered by the Regional Board at its May meeting, lists Desert View Estates as the Owner and Joshua Basin Water District as the Operator of the new facility. The developer has tentatively planned to install the Microfast system with only a single tank in each train and a mixed-liquor recirculation system.

We recommend that the District carefully consider the performance of the existing Biomicrobics system being used at a neighboring Applebee's restaurant. An engineer should observe the nitrogen removal capability of this system over the course of the next few weeks. This will allow the District to determine if the single-tank system with a custom-designed recycle stream will continuously provide the District with single-digit Total Nitrogen effluent levels, or if the enhanced, four-tank treatment train certified by the manufacturer will be required.

Operation and Maintenance Tasks – Membrane Bioreactor Plant

A minimal amount of regular maintenance would be required for an MBR plant. The system is pre-screened, and regular removal of solids from the screen would be required. The pumps and blowers for the skid would require regular maintenance from certified mechanics. Typical maintenance includes changing seals, bearings, and oil as necessary. Major work includes motor and impeller replacement.

The most involved maintenance task for the MBR plant is the chemical clean of the membranes every 3 to 6 months. The membrane system manufacturer is available to train District staff about how to most efficiently carry out this task.

The gravity sewer collection system would require periodic vactor jetting and cleaning, which are normal maintenance tasks in any sewer system. It is possible that breaks in the sewer line could occur during the life of the sewer system. Sewer line maintenance would need to be performed by District staff.

Operation and Maintenance Tasks – Packed Aerobic Reactor Plant

The Packed-Bed Reactor would require similar maintenance tasks, but would not require the in-place chemical cleaning. There would be no membranes to replace. The aforementioned equipment maintenance for pumps and blowers would still be required.

Construction Cost Estimate

It is assumed that the developer would fund the construction of the influent gravity sewer piping between the individual homes and the package plant. Total installed construction costs for the systems are estimated as follows:

- Membrane Bioreactor Package Plant: $900,000
- Packed Aerobic Reactor Plant (with four-step nitrogen removal system): $450,000

These costs include the effluent disposal seepage pits, influent pumps, recirculation pumps, aeration blowers, control panels, buried vaults, slabs on grade, sludge storage tanks, operator touch-screens, and all other mechanical equipment and controls.

It should be noted that the MBR cost is for a slightly larger capacity of 25,000 gallons per day. If the developer were required to install a membrane plant, the District would have the option of reimbursing the developer for the additional capacity.

Operation and Maintenance Costs – Membrane Bioreactor Plant

Every 3 to 6 months, the membranes are taken offline for cleaning. Biosolids are typically pumped into a sludge storage tank and are trucked away by a sludge disposal company. Sludge wasting is manually initiated operated by a discharge valve connected to the sludge storage tank and can be done daily for a few minutes or weekly for 1 to 2 hours.

The following are estimates of the operation and maintenance costs for an MBR package facility:

- Chemical costs for the sodium hypochlorite used during membrane cleaning would be approximately $1,500 per year.
- Sludge disposal costs would run approximately $600 per month ($7,200 per year) for a truck disposal company.
- Labor costs devoted to the treatment skid and sewer system would average about $ 400 per week, which equates to approximately $20,800 per year. This cost is for the labor required to remove the sludge from the storage tank, perform the in-place membrane cleaning, make minor repairs to pump and blowers, clean the influent screens, maintain the gravity sewer system, and keep the facilities clean and operable.
- Electricity costs of approximately $10,000 per year.
- Membrane replacement cost of approximately $3,000 per year. The anticipated life of the membranes is 5 years. The membranes have a full warranty for up to 18 months and a pro-rata warranty for membranes between 18 months old and 5 years old.

The total annual cost of operation and maintenance for the plant and in-development sewer system is estimated at $43,000 per year. Of this cost, approximately $8,000 per year would be devoted to maintain just the collection system for the 61-home development.

Operation and Maintenance Costs – Packed Aerobic Reactor Plant

Costs for solids disposal and electricity would be about the same as for the membrane plant, but labor cost would be reduced slightly because of the reduced complexity of the system. There would be no costs for membrane replacement or chemical cleaning. As such, the annual O & M cost for a packed aerobic reactor plant can be estimated at about $35,000 per year. This includes the cost of maintaining the collection system.

Operator Qualifications

Currently the Regional Board does not require the package plants to be staffed with licensed wastewater treatment plant operators, but John Rokke of the Palm Desert Regional Board Office mentioned the possibility that regulations could change at some stage in the future, such that package plant operators would be required to be licensed by the State of California.

Miscellaneous Considerations

The advantage of the membrane bioreactor systems is that they have come into widespread use in the last five years. As such, there are several wastewater agencies that have staff who are trained to operate the MBRs. There are several training resources available from other agencies and from the membrane manufacturers.

The other advantage of the MBR system is that it can be used to treat wastewater to levels meeting Title 22 requirements for recycled water filtration. The RWQCB only requires secondary treatment for percolation, but the effluent from the MBR would also

meet tertiary filtration standards. The tertiary water produced could be disinfected to meet Title 22 and then used for irrigation of median strips, green belts, or for some local commercial, industrial, or agricultural use.

The disadvantage of the membrane systems is their mixed record of reliability and the possibility of membrane fouling. Membranes at some facilities are replaced more often than the manufacturer literature would suggest.

The Biomicrobics packed-bed reactor system is considerably less expensive. The District has the opportunity to observe the performance of a local similar system installed at the Applebee's Restaurant. This is an opportunity to test the reliability of a custom-designed denitrification system used in conjunction with a packed aerobic bioreactor.

Addendum to Report: Biologically Engineered Single Sludge Treatment System (Addendum Dated May 9, 2006)

Subsequent to the submittal of this feasibility study to the District, a discussion ensued between the developer's engineer, the District, and the RWQCB. This discussion centered around the treatment reliability of the Biomicrobics system. A Biomicrobics system similar to the proposed system was recently installed at the Applebee's Restaurant in Yucca Valley. This system has recently experienced problems with grease fouling and bacterial kill resulting from the introduction of cleaning chemicals in the influent stream. After further review and discussion with the Regional Board, the developer's engineer informed the District that he wished to change the design and recommend a packaged activated sludge system manufactured by Purestream Technologies. The developer's engineer, who is responsible for the design of the treatment facilities, has expressed that he prefers to recommend the Purestream plant instead of the Biomicrobics plant.

The trade name for the Purestream system is the Biologically Engineered Single Sludge Treatment (BESST) System. For the Desert View Estates installation, the system would consist of a single rectangular tank with dimensions of approximately 12 feet wide, 11

feet high, and 35 feet long. A complete activated sludge system would be furnished inside the tank. Influent would enter the tank into a common anoxic zone. The anoxic zone would be fully mixed using submersible mixers furnished with the packaged system.

Downstream of the anoxic zone, the flow splits into two parallel aeration tanks. Each of the tanks contains a series of fine bubble diffusers, which deliver air to maintain a mixed liquor suspended solids (MLSS) concentration between 3,000 and 6,000 mg/L. The air source consists of two positive displacement blowers, installed in a small block building at the ground surface.

Each aeration tank contains a clarifier, in the shape of an inverted triangular trough. The clarifiers are fabricated of steel plate. Mixed liquor from the aeration tank enters the base of the upflow clarifiers. A sludge blanket within the clarifier is maintained, with the top of the blanket between two and three feet below water surface.

The system would be designed to maintain total effluent nitrogen levels at or below 8 mg/L, BOD levels below 10 mg/L, and TSS levels below 10 mg/L. Denitrification is accomplished by recycling mixed liquor from the clarifiers back to the anoxic zone.

A sludge holding tank with a volume of approximately 3,000 gallons would be included in the package plant. This tank would provide approximately 30 days of sludge storage. As such, a vactor truck would need to arrive at the site approximately once per month to pump out the tank.

The developer's engineer is proposing to install the Purestream package system below-grade, with approximately one foot of the tank projecting above the surface. The top of the tank would contain galvanized steel grating with foam insulation. Odors would be minimal because of the foam insulation, high oxygen delivery rate, high MLSS, and mixed liquor return to the anoxic zone.

The projected installed construction cost for a Purestream plant would be between $350,000 and $450,000. Approximately $150,000 of this amount is the material cost of the package plant itself. Other major construction cost components include electrical installation, excavation, a small masonry building for the blowers and electrical equipment, and piping connections to the packaged system. The masonry building would be necessary to attenuate the noise caused by the positive displacement blowers, which operate at fairly high decibel levels.

Operation and maintenance costs for the facility are estimated at approximately $35,000 per year. This includes the cost of maintaining the in-development collection system. For the package plant, major operation and maintenance tasks include cleaning of the influent bar rack, replacement of plugged or broken diffusers, cleaning the aeration tanks, changing the oil in the blowers, and periodically pumping the sludge from the holding tank. Operation of the plant would require periodic adjustment of the wasting rate, recycle rates, and aeration rate, to maintain the appropriate MLSS in the aeration tanks.

It is projected that the Purestream system would consistently maintain the total nitrogen levels below the required average effluent level of 10 mg/L. The Purestream package systems are manufactured in Kentucky, and there are several installations in California that serve as sources of information and operational insight from Districts and other owners of Purestream systems.

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